HIGH-PERFORMANCE ELECTRONICS COOLING SYSTEM

RELATED APPLICATIONS

The present application is a divisional of, and claims priority to, U.S. patent application Ser. No. 15/797,996, titled "HIGH-PERFORMANCE ELECTRONICS COOLING SYSTEM," and filed on Oct. 30, 2017, the entire contents of which are hereby incorporated by reference for all purposes.

BACKGROUND

Cooling systems are traditionally used to dissipate heat generated by electronic circuit packages, such as an integrated circuit die package. Heat pipes and vapor chambers are components of such cooling systems. In addition, liquid cooling solutions are also used to transfer heat generated by such electronic circuit packages (ECPs). As ECP manufacturers develop advanced microprocessors for high-performance processing and computing applications, new advances in ECP cooling solutions are needed to adequately manage the increased heat that is generated by these more advanced components.

SUMMARY

According to one aspect, the disclosure relates to a cooling system for an electronic circuit package. The cooling system includes a heat transfer plate positioned in thermal contact with an electronic circuit package surface. The heat transfer plate forms a bottom surface of an evaporative region of the cooling system. The cooling system further includes a plurality of condensing tubes in fluid communication with, and extending away from, the evaporative region. The evaporative region and condensing tubes together form a single, uninterrupted, sealed enclosure. The cooling system further includes a fluid disposed within the sealed disclosure. The cooling system further includes a plurality of spacers substantially filling gaps between the heat transfer plate and respective condensing tubes. Each of the spacers is configured as an independent component to allow the passage of fluid through an interior space of each spacer. The cooling system further includes a plurality of wicks. Each wick is positioned partially within a corresponding spacer to which the spacer is fluidically coupled.

In some implementations, at a least a portion of each wick contacts the heat transfer plate. In some implementations, the portion of each wick in contact with the heat transfer plate is oriented substantially parallel to the heat transfer plate. In some implementations, the portion of each wick in contact with the heat transfer plate covers less than three-quarters of a cross sectional area of an end of a corresponding spacer. In some implementations, the portion of each wick in contact with the heat transfer plate substantially covers an end of its corresponding spacer and extends in a direction parallel to the heat transfer plate beyond an edge of the corresponding spacer. In some implementations, each wick comprises a metal mesh. In some implementations, each spacer extends at least partially into a corresponding condensing tube. In some implementations, an inner surface of each condensing tube defines a plurality of grooves. In some implementations, the heat transfer plate comprises a plurality of fins extending away from the heat transfer plate within the sealed enclosure. In some implementations, the plurality of fins are arranged in an irregular fashion. In some implementations, the plurality of fins are arranged based on a variation in heat generation across the electronic circuit package surface in thermal contact with the heat transfer plate. In some implementations, at least a portion of the sealed enclosure is coated with a copper powder. In some implementations, the copper powder coating the sealed enclosure has a particle size of about 0.1 mm. In some implementations, the copper powder coating the sealed enclosure forms a coating having a thickness of about 0.3 mm. In some implementations, the copper powder coating coats a plurality of fins extending away from the heat transfer plate within the sealed enclosure. In some implementations, the copper powder coating coats at least one of the heat transfer plate and a surface of the evaporative region opposite the heat transfer plate within the sealed enclosure. In some implementations, the interiors of the condensing tubes are free from the copper powder coating. In some implementations, a diameter of each spacer flares outward proximate to the heat transfer plate. In some implementations, a portion of each spacer extends closer to the cooling plate than a remainder of the spacer. In some implementations, the condensing tubes are positioned about a perimeter of the sealed enclosure.

According to another aspect, the disclosure relates to a cooling system for an electronic circuit package. The cooling system includes a heat transfer plate positioned in thermal contact with an electronic circuit package surface. The heat transfer plate forms a bottom surface of an evaporative region of the cooling system. The cooling system further includes a plurality of condensing tubes in fluid communication with, and extending away from, the evaporative region. The evaporative region and condensing tubes together form a single, uninterrupted, sealed enclosure. Each of the plurality of condensing tubes includes a plurality of grooves. The cooling system further includes a fluid disposed within the sealed disclosure. The cooling system includes a plurality of wicks. Each wick is positioned such that one end is in contact with the heat transfer plate and an opposite end extends into a proximal end of a corresponding condensing tube for a distance that is less than 5% of the length of the corresponding condensing tube. In some implementations, each wick comprises a multi-layer copper mesh.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and related objects, features, and advantages of the present disclosure will be more fully understood by reference to the following detailed description, when taken in conjunction with the following figures, wherein:

FIG. **1** is a diagram of an example electronic circuit package cooling system.

FIGS. **2**A-**2**G describe multiple example configurations of spacers and wicks suitable for use in an electronic circuit package cooling system according to some implementations.

FIG. **3** is a top view of the example electronic circuit package cooling system illustrating an example arrangement of condensing tubes in an electronic circuit package cooling system according to some implementations.

FIG. **4** is a diagram of the electronic circuit package cooling system illustrating an example arrangement of grooved condensing tubes in an electronic circuit package cooling system according to some implementations.

FIGS. **5**A and **5**B are diagrams of example configurations of fins suitable for incorporation into an electronic circuit package cooling system according to some implementations.